ENERGY MANAGEMENT CONSULTATION AND TRAINING (EMCAT):

HYATT REGENCY HOTEL SURVEY

RESOURCES MANAGEMENT ASSOCIATES OF MADISION, INC.

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HYATT REGENCY HOTEL - NEW DELHI

HR-1 Executive Summary

The Hyatt Regency Hotel is located in New Delhi. The facility has seven guest floors (525 rooms), a service floor housing piping, a main lobby floor, a ground floor, and a basement which houses mechanical rooms and support services (see *Figure HR-1*). The hotel is 12 years old. Guest amenities include three restaurants, a swimming pool, banquet halls, a fitness club, and a business center. The top two floors of the hotel house the Regency Club. The Regency Club has a private lounge, a business center, and luxuriously appointed suites and rooms.

This report looks at the facility's existing energy consumption patterns, provides a description of the building's energy-using systems and previous facility energy conservation activities, and presents recommendations based on calculations provided in this report. (See Appendix HR-A.)

The hotel's energy sources are electricity, light diesel oil (LDO), high-speed diesel (HSD), and liquefied petroleum gas (LPG). Of these, electricity is the most important as it represents 92% of the hotel's energy cost. This is followed by LDO at 8%. HSD and LPG were reported to be very small. *Table HR-2* summarizes facility energy consumption and associated energy pricing.

Together, the survey team and facility staff identified 14 Energy Conservation Opportunities (ECOs). After analysis of the opportunities, 12 are recommended for implementation. The total savings of the twelve recommended ECOs would be Rs. 9,700,000 (US$ 313,000). With an implementation cost of Rs. 29,200 (US$ 940,000), the average payback is 3.0 years. This savings equals 15% of the hotel's energy budget. Interactions among the ECOs may slightly reduce total savings.

In addition to each opportunity's explanation in the body of this report, the analysis to evaluate their cost-effectiveness is presented in Appendix HR-A.

The survey team recommends that the facility management hire local engineering consultant(s) to help in the design and implementation of those ECOs not familiar to the facility's technical staff.

Table HR-1
Summary of Estimated Savings from Implementation of Recommended ECOs

Description of Recommended ECO	**Implementation Cost (Rupees)**	**Anticipated Annual Savings (Rupees)**	**Investment Payback (years)**	**Light Diesel Oil Annual Savings (liters)**	**Electricity Annual Savings (kWh)**
ECO # 1 Variable Speed chilled Water (CW)	3,370,072	815,847	4.1	-	271,949
ECO # 2 Direct-Fired Absorption Chillers	NOT RECOMMENDED				
ECO # 3 High-Efficiency Centrifugal Chillers	13,485,000	4,583,303	2.9	-	1,527,768
ECO # 4 Cooling Tower Plant Controller	465,000	330,326	1.4	-	110,109
ECO # 5 Provide a Dedicated Facility Energy Conservation Staff	360,000	652,668	0.6	7,700	200,000
ECO # 6 Lighting Efficiency Upgrades	1,230,510	664,717	1.9	-	221,610
ECO # 7 Boiler Exhaust Stack Heat Recovery	279,000	368,249	0.8	53,836	-
ECO # 8 Boiler Fuel Atomization & Burner Modulation Control	682,000	158,004	4.3	23,100	-
ECO # 9 Boiler Insulation Upgrade	13,702	15,252	0.9	2,250	-
ECO #10 Steam Distribution/Condensate Return	PROVIDED FOR REFERENCE				
ECO #11 Guest Room Lighting Control	3,255,000	603,386	5.4	-	201,075
ECO #12 Solar Preheating for Domestic Hot	5,251,400	945,066	5.6	138,167	-
ECO #13 High-Efficiency Motors for Air-Handling	604,469	327,450	1.9	-	109,150
ECO #14 Water Consumption Reduction	244,125	276,985	0.9	24,021	2,725
TOTALS	**29,240,278**	**9,741,253**	**(avg.) 3.0**	**249,074**	**2,644,386**

HR-2 Description of Facility

The Hyatt Regency Hotel is a five-star luxury hotel located in New Delhi. The building itself is owned by the Asian Hotel Group, but the hotel is operated by the Hyatt Group. Other Hyatt hotels in the vicinity are located in Goa and Katmandu. Guests who use this hotel are primarily foreign business travelers, although wealthy foreign tourists also use the facility.

The Hyatt Regency in New Delhi was completed in 1982. It has seven guest floors which contain 525 guest rooms. The guest rooms range from standard single room accommodations to multi-room suites. In addition to the guest rooms, the hotel offers three restaurants, a drinking lounge, banquet halls, a fitness club, a business center, a shopping mall, an outdoor swimming pool, and a tennis court. (See *Figure HR-1*.)

The building is of masonry construction windows in every room. The windows are sealed to prevent air leakage.

Maintenance and improvements to the hotel are made by an in-house engineering and maintenance department. This department is responsible for energy conservation activities.

HR-3 Facility Energy Use

The major sources of energy consumption are electricity and LDO. LPG and HSD are also used in the hotel, although quantities were reported to be quite small. Electricity is provided by a local utility, whereas LDO and LPG are purchased and stored in tanks. See *Table HR-2* for rates.

Reliability of electrical supply was not reported to be a problem. This would explain the insignificant amount of HSD consumption.

Of the various energy types used at the hotel, electricity is the largest piece of the energy budget. Electricity commands 92% of the energy budget and LDO makes up 8%. LPG, which is typically used in kitchens, and HSD which is used in backup electrical generation, represent a very small part of energy costs. Records provided to the survey team did not include the costs of LPG or HSD.

The energy consumption profile for the nineteen months between January 1994 and July 1995 (see *Figure HR-2* and *Table HR-3*) shows electricity consumption to be quite variable. This is because of the large air conditioning load during the summer months. The price per unit of electricity during this period was increasing. The cost of electricity is expected to continue to increase given the shortage of electrical supply throughout India.

Figure HR-1
Hyatt Regency Hotel - New Delhi

Table HR-2
Hyatt Regency Hotel Total Energy Consumption

Description	Electricity	High-Speed Diesel (HSD)	Light Diesel Oil (LDO)	Liquefied Petroleum Gas (LPG)
High Heating Value				
kcal/kg		9,500	10,700	11,642
Btu/lb		17,106	19.267	20,963
Btu/liter		35,000	36,454	23,481
Average Density				
kg/liter		0.93	0.86	0.51
Annual Consumption				
kWh	20,000,000			
liters		N/A	770,000	
kg				N/A
MMBtu		0	28,115	0
Average Cost per Unit				
In Local Currency,				
per kWh	3.00			
per liter		N/A	6.84	
per kg				N/A
In $US				
per kWh	0.10			
in US$/MMBtu	28.35	0.00	6.04	0.00
Annual Cost				
In Local Currency	60,000,000	0	5,266,800	0
In US$	1,935,000	0	169.897	0
In % of Fuel Costs	91.9	0	8.1	0
Total Annual Energy Expenses				
In Local Currency	65,266,800			
In US$	2,105,381			

Local currency: Rupee (Rs.)
Exchange Rate: 1 US$ = 31 Rs.

Figure HR-2
Hyatt Regency Energy Consumption Profile – January 1994 - July 1995

Table HR-3
Hyatt Regency Energy Use and Rates – January 1994 - July 1995

HR-4 Description of Existing Energy-Using Systems

Air Conditioning

The peak building air conditioning load is approximately 1,320 tons. Air conditioning is provided by a chilled water (CW) system consisting of four chillers (see Appendix HR-B, photo 2) and three pumps. A schematic of the system is shown in *Figure HR-3*. The pumps and chillers are configured in what is known as a parallel arrangement. The pumps are connected to the chillers via a common pipe, also known as a common header, which allows any one pump to be used with any given chiller. The hotel mechanical staff operates the chiller and pump combinations necessary to meet the space cooling loads. These chillers and pumps are brought on or off line manually to maintain a constant CW supply temperature. Typically, this ranges from between 6.7°C (44° F) and 10°C (50°F), depending on the season and air conditioning load.

The system design consists of chilled water coils (CWC) located in air-handling units (AHUs) and fan coil units (FCUs). The AHUs serve the public spaces, while the FCUs serve each individual guest room. Outside air (ventilation air) is provided to the guest rooms by AHUs.

The control strategy consists of three-way, two-position bypass automatic control valves at each FCU cooling coil and no control at the AHU cooling coils. The three-way valves are controlled by thermostats located in the guest rooms. On a call for cooling from the thermostat, the three-way valve is opened to allow full flow of chilled water through the cooling coil. Once the thermostat set point is satisfied, the control valve is opened to the full bypass position. The AHUs without any control rely on occupant feedback for maintaining comfort. If the occupants report the space to be too cold, the respective AHU is turned off. The unit is turned on again as requested by the occupants.

The CW piping system does not contain any means of balancing the pressure drops and flows to the various loads in the system. This is not a desirable situation since short-cycling of water is likely to occur and deprive the coils downstream of the flows required to meet the loads. At present, the only means available to satisfy the furthest coils is to increase the system pressures and flows through the CW pumps. This results in over pumping, lack of temperature control, and increased operating costs. These situations can be corrected by balancing the flow in the system. There are typically two ways of achieving flow balance in the system: calibrated balancing valves or properly selected automatic control valves.

The air control on the CW system consists of automatic air vents located in the return piping at the roof terrace level. The expansion make-up tank consists of an open tank located on the roof terrace and connected to the CW return pipe at this level. The open tank provides a surface for air, particularly oxygen, to enter the CW system.

Entrained oxygen has two major undesirable consequences: (1) it reacts with the steel pipe and leads to corrosion of the pipe and (2) being a poor conductor of heat, it lowers the heat transfer, and thus efficiency, at the coils. It is recommended that a compression tank and a centrifugal air separator be installed in the system.

Heat is rejected by multiple cooling towers piped in parallel. Similarly, the cooling tower pumps are also arranged in parallel (see *Figure HR-3*). The pumps and tower fans are brought on manually as the load increases. The load is monitored using the refrigerant head pressure in the chiller and the condenser water supply temperature. The operator is able to determine whether to bring on additional cooling towers and pumps or to turn them off.

Both the CW and condenser water are treated for hardness. This is good for the system as it minimizes scaling in the piping and, more importantly, in the coils and the tube surfaces of the chiller. There is, however, no treatment being done to control biological growth and corrosion. Both are important as they affect the longevity as well as efficient operation of the system. Algae formation in the cooling tower sumps was reported as being a problem. Corrosion problems were not prominent, mainly because of the wood construction of the cooling towers. A water treatment schedule is recommended as it will reduce maintenance while improving system endurance and performance.

Air-Handling Systems

The AHUs are single zone, packaged units, each containing permanent filters made from fibrous material, a four- or six-row cooling coil, and a centrifugal supply fan (see Appendix HR-B, photo 4). The supply air is ducted, while return air utilizes return air plenum formed by the space above the false ceilings (see *Figure HR-4*).

Supply air is introduced into the public areas through continuous grilles that are a combination supply and return. This arrangement is not very desirable as it leads to short-cycling of part of the supply air directly into the return air plenum.

Outside air is introduced into the return air plenum through a louver opening located in the outside wall near the AHU. In most cases, these openings were found to be blocked off. According to the hotel's mechanical staff, infiltration directly into the public areas was being used as the source of ventilation. This is not a recommended means of meeting the building's ventilation needs. There are two concerns with this method: (1) The amount of infiltration is uncontrolled and will result in loss of building air balance or pressure control. (Building pressure control is essential for proper functioning of the ventilation and exhaust systems.) (2) If the building were to be negatively pressurized relative to the outside, unconditioned outside air would be introduced directly into the space resulting in loss of space temperature control and comfort.

Most AHUs are started and stopped based on use or occupancy of the space. The lobby and the guest room ventilation AHUs are run twenty-four hours a day. The AHUs in other areas are typically run during office hours, whereas the banquet hall units are run only during the time when functions are taking place.

Figure HR-3
Schematic of Existing Air Conditioning System

Ventilation air to the guest rooms is provided by two central AHUs which run continuously. The units bring in 100% outside air, cool it to approximately 65°F, and then distribute it to each guest room. This system is designed to introduce 50 to 60 cubic feet per minute (cfm) of ventilation air into each room. The air is introduced into the space.

Air balancing dampers were typically not used, and if they were, they had very high leakage rates making them obsolete in function. Balancing dampers are useful for setting the right amount of air required by the space. This can improve comfort in the spaces as well as reduced airflow requirements at the fan.

Figure HR-4
Schematic of Typical Air-Handling Unit (AHU) Serving a Public Area

Exhaust Systems
The building exhaust system consists of central exhaust fans with distributed exhaust ductwork. Air-balancing dampers were not used, so the grilles farthest from the exhaust fans were starved of air. These fans run continuously.

The kitchens are equipped with kitchen exhaust hoods. The outside air for some of the kitchen hoods is introduced into the space through a dedicated AHU, which uses air washers to evaporatively cool the air. However, in the kitchen for the Cafe Restaurant the fresh air is conditioned from the central chilled water system. The kitchen exhaust hood fans are generally operated a few hours during lunch and then again during dinner time. The exhaust fans are typically located on the roof terrace and consist of centrifugal fans mounted in an exhaust air plenum.

The exhaust ductwork is a low-velocity system. This is not good for kitchen hoods, since the air is generally carrying grease vapors which can get deposited in the ductwork at low air velocities. This deposited grease in the ductwork could also become a potential hazard in case of fire outbreak below the kitchen hood.

Heating Systems
New Delhi has a relatively cool winter (low temperature of 5°C) which requires buildings to be equipped with central heating systems. Heating is generally required for only one or two weeks in the year. Heating is accomplished by circulating hot water through the same piping and coils as the chilled water system. The system is switched over to the winter mode by isolating the chiller plant and opening the gate valves at the tie-in piping from the heat plant. This changeover is done manually by the operating staff, based on the needs of the occupants. A separate set of pumps is used for the distribution of hot water, and heating is only provided in the guest rooms.

Steam Production
Steam is produced to make domestic hot water, heat for drying clothes, and heat for cooking. The boiler room has two 2,000 kg/hr water tube boilers. (See Appendix HR-B, photo 3.) The boilers utilize LDO which is similar to a Number 2 fuel oil. Only one boiler is run at a time, with the other serving as a backup. The boiler is used for about 16 hours each day throughout the year. Steam is not needed when the laundry and main kitchens are closed.

The boilers are forced-draft with mechanical fuel oil pressurization. The burner operates using a high/low/off control strategy based on steam pressure. Typical operating pressure is 110 to 130 psig of saturated steam. Boiler tuning is presently based on manual measurements of CO_2 in stack gases. The target amount of CO_2 is 12 -13%. The boiler make-up water is softened in a primary softener, and blowdown is regulated by manual measurement of hardness, pH, and NaCl. The percent of condensate recovery is currently unknown, although feed water averages 71°C (160°F). It could not be determined whether or not steam was used to preheat feed water. Stack temperature was measured as 205°C (400°F) on low fire and 211°C (412°F) on high fire. Presently, no stack heat recovery is in place.

Several opportunities exist to increase fuel utilization efficiency. The first is to install a burner package which will allow atomization of fuel by using compressed air along with a burner that has modulation capability. These will provide an improved flame pattern despite varying viscosities of fuel; changing viscosities of fuel are reported to be common. In addition, a modulating burner will reduce the purge cycle loss.

The survey team observed that stack heat recovery is not practiced. Recovering lost heat in the boiler exhaust will improve fuel utilization efficiency. Recovering heat from the exhaust stack gases and preheating boiler feed water with the recovered heat will reduce energy consumption.

The ends of the boilers have high surface temperatures. By installing additional insulation on the ends of the boilers, heat loss can be reduced. Care must be taken to allow for maintenance access after the insulation is installed.

These ECOs are described in Section HR-6 of this report. Calculations to quantify the benefits are presented in Appendix HR-A.

Lighting

The primary lighting technologies include incandescent bulbs and four-foot fluorescent lights with electronic ballasts. Specialty lighting, including low-voltage lighting, is used in restaurants. Mirrored reflection lamps are used in the guest rooms as entry way lights.

Since aesthetics are important in a hotel, the “look” of the lighting in critical. The reliability of lighting is also important because burned out lights in guest areas are an inconvenience to the guests and a maintenance problem.

The hotel lobby is fit with 60-watt incandescent bulbs in recessed can fixtures. The restaurants use a combination of special low-voltage downlighting and standard small-wattage incandescent bulbs. Corridors are lit with indirect fluorescent lights, seven-watt compact fluorescent lamps (CFLs), or 25-watt decorative incandescent bulbs. The guest rooms use 100-watt incandescent bulbs, and pairs of 25-watt flame-shaped incandescents light the bathrooms. Four-foot fluorescents are used in all service areas.

The hotel has already taken advantage of electronic ballasts. They are experiencing short lamp life which should be examined by the lamp manufacturer. Problems with ballast wiring, ballast/lamp compatibility, and lamp placement in the fixture can shorten lamp life drastically.

Seven years ago the facility implemented CFLs for a limited application. To date, the staff has been satisfied with this technology's performance. Since the time of the implementation, the quality of light and the appearance of the fixture have been improved dramatically. The new CFLs will expand the acceptable implementation areas.

Where CFLs are not accepted, tungsten halogen capsylite would be a good alternative. They reduce energy consumption by 30% while looking very similar to a standard incandescent bulb. Section HR-6 expands upon particular lighting opportunities identified during the survey.

Domestic Water Heating

Domestic water heating includes the hot water for guest rooms, kitchens, laundry, health club, and maintenance. Hot water is produced by a “calorifier”. The calorifier is a large tank which has a high-temperature hot water coil inside of it. As domestic hot water is used, cold make-up water is supplied to the tank. The hot water coil is operated to keep the water inside the tank at a constant 55°C (131°F).

The high-temperature hot water coil is supplied by two hot water boilers. These boilers are in a continuous piping loop that transfers heat from the boiler into the calorifier.

The hot water boilers are made by Hydrobloc. They are model 600W, and their capacity is 11,000 liters per hour at 65°C (149°F).

An energy-saving opportunity exists in the preheating of the incoming cold water. Given the large amount of solar energy available in India, city water could be preheated prior to entering the calorifier. Final heating in the calorifier will ensure a constant hot water temperature regardless of sunlight availability.

Section HR-6 discusses this recommendation. Analysis of the savings potential is presented in Appendix HR-A.

HR-5 Energy Conservation History

The hotel’s engineering and maintenance department has implemented a wide variety of ECOs in the past. Their motivation to conserve energy is provided by the operating cost reduction associated with reducing energy usage.

The following ECOs, implemented earlier, were identified in the course of this survey.

- The hotel converted its core and coil fluorescent ballasts to electronic ballasts which reduced the fixtures' energy consumption by 30%
- Compact fluorescent lamps were installed in hallway downlighting in 1988
- Digital CO_2 monitors were installed on the steam boilers to monitor and adjust boiler performance
- A “globed” CFL is being tested in the lobby downlighting for its aesthetics and durability

- Tracking of energy consumption is done, and trending graphs are posted in the Chief Engineer's office (See Appendix HR-B, photo 1.)
- LED exit signs were installed
- 50-watt "cat eye" or MR 12-volt lamps were replaced with 20-watt tungsten halogen models
- Energy committee meetings are held every two months

The hotel demonstrates a great aptitude for energy conservation as evidenced by these actions. The following section describes additional ECOs identified during the survey which would help continue this effort.

Details of each measure and the calculations of the potential energy cost savings are presented in Appendix HR-A of this report.

HR-6 Summary of ECOs

Following is a summary of the potential ECOs that were identified and studied. The complete calculations are given in Appendix HR-A.

The ECOs presented in this report are based on information received during the survey. Cost estimates are based on United States pricing at the time of the survey. From this, estimates were calculated and are presented in Appendix HR-A.

Assumptions were made in a conservative direction. If the facility wishes to recalculate the savings based on modified conditions, Appendix HR-A will guide this calculation.

ECO - 1: Variable Speed Chilled Water (CW) Distribution

The existing chilled water system is controlled manually by operating combination of chillers and pumps to meet space cooling load requirements; however, comfort and energy efficiency can be improved by converting to a primary/secondary system with variable speed distribution and automatic controls.

With a primary/secondary configuration, chilled water generation and distribution functions are separated. The chillers are located in the primary loop and generate the CW. A distribution pump located in the secondary loop conveys the CW to the air handling and fan coil units that provide cooling to the various spaces.

The primary/secondary loops have separate pumps. This allows the secondary pump speed, and thus flow, to be varied to match the cooling load without affecting operation of the chillers which require a constant flow at all loads. Since there are a significant number of hours in the year when the cooling load is below design maximum and the CW flow requirements are correspondingly reduced, a variable speed drive allows the pump to operate at slower speeds. This reduces pump brake horsepower requirements and thus the energy consumed by the pump. The following benefits are estimated for this measure.

Annual Energy Cost Savings:	Rs. 815,847 (US$ 26,317)
Annual Electricity Saved:	271,949
Implementation Costs:	Rs. 3,370,072 (US$ 108,712)
Simple Payback:	4.1 years

(See Appendix HR-A for detailed descriptions and calculations involved with this ECO.)

ECO - 2: Direct-Fired Absorption Chiller(s)

The existing electric chillers were compared with two 700-ton, two-stage, direct-fired absorption chillers that use LDO as their fuel.

These units can be installed after removal of the existing electric chillers and with some modifications to the existing cooling tower and chilled water piping inside the chiller plant room. LDO supply piping and combustion intakes would also be needed. In addition, the products of combustion would need to be removed. This would require the installation of an exhaust stack.

The economic feasibility of absorption cooling depends on the cost of the alternative fuel sources, in this case LDO. Higher electricity rates as compared to LDO will favor absorption cooling. Using the present utility rates for both electricity and LDO, the approximate monthly run time and the COP of the existing chillers and the absorption units, an economic analysis was conducted to calculate the following simple payback.

Annual Energy Cost Savings:	Rs. 139,779 (US$ 4,509)
Annual Electricity Saved:	271,949 kWh
Implementation Costs:	Rs. 28,923,000 (US$ 933,000)
Simple Payback:	> 20 years

(See Appendix HR-A for detailed descriptions and calculations involved with this ECO.)

ECO - 3: High-Efficiency Centrifugal Chillers

The existing electric chillers are approximately twelve years old. The efficiency of these chillers is lower than that of chillers available today. Also, the existing chillers use R-11, which is an ozone-depleting refrigerant. This refrigerant has been banned under the Montreal Protocol and will be phased out of production by the end of 1995. Only recycled R-11 will be available thereafter. It is anticipated that the price of recycled R-11 is likely to go up significantly. Therefore, operating R-11 machines in the future will be more expensive, especially if the refrigerant has to be replaced regularly to overcome losses due to leaks or maintenance repair.

This ECO evaluates replacing all the existing chillers with three 500-ton, high-efficiency centrifugal chillers that have a lower kW/Ton rating and use non-CFC refrigerants, such as HCFC-123 or HFC-134a. These units can be installed after removal of the existing electric chillers with relatively few modifications to the existing cooling tower and chilled water piping inside the chiller plant room. The following benefits are estimated for this measure.

Annual Energy Cost Savings:	Rs. 4,583,303 (US$ 147,848)
Annual Electricity Saved:	110,109 kWh
Implementation Costs:	Rs. 13,485,000 (US$ 435,000)
Simple Payback:	2.9 years

(See Appendix TP-A for detailed descriptions and calculations involved with this ECO.)

ECO - 4: Cooling Tower Plant Controller

At the present time, the cooling tower fans and pumps are brought on manually to maintain a constant condenser supply temperature to meet the system load. With a cooling tower plant controller, the condenser supply water temperature set point could be reset to a lower value during cooler months. This would result in energy savings from more efficient chiller operation. In addition, starting and stopping of these fans and pumps can be controlled with greater accuracy to match the system load more closely thereby eliminating excessive fan or pump run time. The following benefits are estimated for this measure.

Annual Energy Cost Savings:	Rs. 330,326 (US$ 10,655)
Annual Electricity Saved:	110,109 kWh
Implementation Costs:	Rs. 456,000 (US$ 15,000)
Simple Payback:	1.4 years

(See Appendix HR-A for detailed descriptions and calculations involved with this ECO.)

ECO - 5: Provide a Facility Energy Conservation Staff

A common obstacle to energy conservation is finding staff time in the daily duties to identify and implement energy conservation opportunities. If a technical staff member's duties are shared between both facility operations and energy conservation, he typically must put energy conservation as a second priority. Since it is rare for facility staff to be caught up with their work, the energy conservation opportunities are usually delayed. Given the large expenditures on energy, a dedicated energy conservation staff will easily pay for their salaries through the reduction and avoidance of energy costs.

The staff should include one engineer, one mechanical technician, and one electrical technician. This staff will be responsible for identifying, prioritizing, designing, implementing, and tracking results of energy conservation opportunities. This staff will also be responsible for finding funding for the energy conservation opportunities. Sources of funding not only include in-house financing, but also such arrangements as shared savings with energy service companies.

The entire facility staff is an excellent resource for locating energy conservation opportunities. This resource is not usually used. With a facility energy manager, there is a continuous source of energy awareness, training, and a point of contact to submit conservation ideas. An energy manager solicits input from the entire facility staff. Contests and rewards motivate employees to seek creative ways to save energy without negatively affecting operation quality.

The energy conservation staff is a profit center. They will not only pay for their salaries, but they will also generate revenue for the facility by reducing overhead costs. By reducing or preventing energy consumption by only one percent, the energy conservation staff will pay for their salaries, and generate a profit of Rs. 250,0000 (US$ 9,400) per year.

(See Appendix HR-A for detailed description and calculations involved with this ECO.)

ECO - 6: Lighting Efficiency Upgrades

The hotel has implemented many high-efficiency lighting measures in the past. Although they have not retrofitted incandescent light bulbs in guest rooms or the lobby's recessed lighting because of concerns about aesthetics.

Two high-efficiency light sources are available to replace the incandescent bulbs in these situations. The most efficient alternative is the electronically ballasted CFLs with a triphosphor coating. They produce the same color of light as the incandescents while reducing the electrical consumption by 80%. The second alternative is the tungsten halogen capsylite which looks almost exactly like a standard "A"-shape incandescent. The tungsten halogen capsylite directly replaces the incandescents while reducing energy by 30%.

The 42-watt tungsten halogen capsylites could replace the existing 60-watt incandescents in the lobby and elevator landings. The higher first cost of these lamps will be compensated for by the energy cost saved and the longer life of the bulbs.

The 15-watt and 24-watt CFLs would ideally replace the incandescents found in the guest room lamps. They would produce the same color of light while hiding their bulbs from view. The CFLs high first cost will be paid for by the reduced energy cost and significantly longer bulb life.

The following benefits are estimated for these measures.

Annual Energy Cost Savings:	Rs. 664,717 ($US 21,442)
Annual Electricity Savings:	221,610 kWh
Implementation Costs:	Rs. 1,230,510 (US$ 39,694)
Simple payback:	1.9 years

(See Appendix TP-A for detailed descriptions and calculations involved with this ECO.)

ECO - 7: Boiler Exhaust Stack Heat Recovery

The hotel staff presently monitors and operates their boilers very carefully. Even with the present boiler operation, several energy conservation opportunities exist which will reduce fuel consumption while producing the same pressure steam.

Because exhaust gas temperature cannot be less than the steam temperature, 15 to 30% of the boilers fuel value is lost up the exhaust stack. A method to capture this lost heat is installation of a stack heat recovery heat exchanger. The heat from the stack would be used to preheat boiler feed water. For every 11 degrees the boiler feedwater is increased, the boiler efficiency would be increased by 1%. The following benefits are estimated for these measures.

Annual Energy Cost Savings:	Rs. 368,249 (US$ 11,879)
Annual Light Diesel Oil Savings	53,836 liters
Implementation Costs:	Rs. 279,000 (US$ 9,000)
Simple Payback	0.8 years

(See Appendix HR-A for detailed descriptions and calculations involved with this ECO.)

ECO - 8: Boiler Fuel Atomization and Burner Modulation Control

Presently, the boiler is operated using a high/low/off control strategy. As with most equipment, starting and stopping leads to inefficiency. By implementing a modulating burner, the boiler will operate continuously at varied loads. This modulation will reduce fuel consumption by 0.8% on average.

Fuel consistency was noted to be a problem in all facilities visited. Boilers which use only pump pressure for atomization typically are 2 to 8% less efficient than boilers which atomize the fuel using compressed air. This opportunity is to install air atomization when installing the modulating burner. This combination will maintain a consistent flame pattern even with variances in the viscosity of fuel received.

A conservative estimate anticipates an efficiency improvement of 3% by upgrading the two burners. The following benefits are estimated for these measures.

Annual Energy Cost Savings:	Rs. 158,007 (US$ 5,097)
Annual Light Diesel Oil Savings:	23,100 liters
Implementation Costs:	Rs. 682,000 (US$ 22,000)
Simple Payback:	4.3 years

(See Appendix HR-A for detailed descriptions and calculations involved with this ECO.)

ECO - 9: Boiler Insulation Upgrade

Because of annual maintenance required on boilers, it is common for the front and back of boilers to lack exterior insulation. This increases convenience while performing maintenance, but also creates boiler heat loss which leads to very warm boiler rooms. This opportunity is to install board- or blanket-type high-temperature insulation on the ends of the boiler. The following benefits are estimated for these measures.

Annual Energy Cost Savings:	Rs. 15,252 (US$ 492)
Annual Light Diesel Oil Saved:	2,250 liters
Implementation Costs:	Rs. 13,702 (US$ 442)
Simple Payback:	0.9 years

(See Appendix HR-A for detailed descriptions and calculations involved with this ECO.)

ECO - 10: Steam Distribution/Condensate Return Efficiency

The steam distribution system in general was in very good shape and well insulated. This energy conservation opportunity is to perform a routine review of the steam distribution and condensate return piping. The tables presented in Appendix HR-A show will help quantify the energy cost saved by repairing steam and condensate leaks and by replacing damaged and missing insulation . This ECO is presented for reference purposes.

(See Appendix HR-A for detailed descriptions and calculations involved with this ECO.)

ECO - 11: Guest Occupancy Controls

When leaving their rooms, hotel guests are typically not very good at remembering to shut lights off. To accommodate this, many hotels install systems which use the guest's key chain to control lighting. This ECO addresses the installation of occupied/ unoccupied controls based on a guest key system. This automation adds an additional feature to ensure guest comfort and convenience without leaving lighting run unnecessarily. The following benefits are estimated for these measures.

Annual Energy Cost Savings:	Rs. 603,386 (US$ 19,464)
Annual Electricity Savings:	201,075 kWh
Implementation Costs:	Rs. 3,225,000 (US$ 104,032)
Simple Payback:	5.4 years

(See Appendix HR-A for detailed descriptions and calculations involved with this ECO.)

ECO - 12: Solar Preheating for Domestic Hot Water

Hotels require a large amount of domestic hot water. This water enters the facility at 20°C (68°F) and is heated to 55°C (130°F). This opportunity is to install solar panels to preheat the domestic water from 20°C to 32°C (68°F to 90°F). The remaining heat will be added in the calorifier. This allows one-third of the energy to be provided for by the sun. Regardless of the amount of preheating which is done, the water will be heated to the final temperature in the calorifier. The following benefits are estimated for these measures.

Annual Energy Cost Savings:	Rs.391,216 (US$ 92,400)
Annual Light Diesel Oil Saved:	57,195 liters
Implementation Costs:	Rs. 5,251,400 (US$ 169,400)
Simple Payback:	5.6 years

(See Appendix HR-A for detailed descriptions and calculations involved with this ECO.)

ECO - 13: High-Efficiency Motors for Air-Handling Units

The air-handling units for public spaces are operated by small motors, typically 10 horsepower in size. Although small, they have a large amount of run hours. This is especially true in areas like lobbies and in 24 hour-per-day restaurants. It is recommended to retrofit each of the existing motors with a high-efficiency motor. The difference in efficiency will be approximately 6%.

High-efficiency motors run cooler and last longer than standard-efficiency motors. This will reduce air conditioning and maintenance costs. The following benefits are estimated for these measures.

Annual Energy Cost Savings:	Rs. 327,450 (US$ 10,563)
Annual Electricity Saved:	109,150 kWh
Implementation Costs:	Rs. 604,469 (US$ 19,499)
Simple Payback:	1.9 years

(See Appendix HR-A for detailed description and calculations involved with this ECO.)

ECO - 14: Water Consumption Reduction

Water consumption relates to energy conservation in two ways: First, it requires electrical pumps to pressurize the water and to move the water around the building. Second, hot water is generated by heating it with hot water boilers. Any instance where water is used in excess, or is leaked, is an opportunity for energy conservation.

This ECO identifies two measures which will reduce water usage. The first is to install flow controlling shower heads. Typically, the flow of water for shower use is in excess of what is necessary to have a comfortable shower. Shower heads have been developed which control the pattern and flow of water so that the user is satisfied and the consumption is reduced by 50%. The second measure is to conduct a routine review of plumbing fixtures such as sink faucets, toilets, and water valves to locate leakage. The repair is typically inexpensive and simple.

Annual Energy Cost Savings:	Rs. 172,143 (US$ 5,553)
Annual Water Cost Savings:	Rs. 104,842 (US$ 3,382)
Annual Electricity Savings:	2,725 kWh
Annual Light Diesel Oil Savings:	24,021 liters
Implementation Costs:	Rs. 244,125 (US$ 7,875)
Simple Payback:	0.9 years

(See Appendix HR-A for detailed description and calculations involved with this ECO.)

HR-7 Recommendations

Of the ECOs summarized in the previous section, the following are recommended for implementation. Payback was used as the main selection criterium. In some cases the ECOs were alternatives for the same opportunity, and so the one with the lower payback was selected. The ECO involving solar water heaters was recommended even though it has a slightly higher payback, because there are tax incentives available that would make the payback period shorter than was calculated here.

ECO # 1 Variable Speed Chilled Water (CW) Distribution
ECO # 3 High-Efficiency Centrifugal Chillers
ECO # 4 Cooling Tower Plant Controller
ECO # 5 Provide a Dedicated Facility Energy Conservation Staff
ECO # 6 Lighting Efficiency Upgrades
ECO # 7 Boiler Exhaust Stack Heat Recovery
ECO # 8 Boiler Fuel Atomization and Burner Modulation Control
ECO # 9 Boiler Insulation Upgrade
ECO #11 Guest Room Lighting Control
ECO #12 Solar Preheating for Domestic Hot Water
ECO #13 High-Efficiency Motors for Air-Handling Units
ECO #14 Water Consumption Reduction

ECO #2 is not recommended and ECO #10 is provided for informational purposes.

APPENDIX HR-A
ECO Calculations

ECO # 1

VARIABLE SPEED CHILLED WATER (CW) DISTRIBUTION

Description of ECO

Under this ECO, the existing CW system would be modified into a primary/secondary configuration. This will separate the CW generation from the distribution. The primary loop will consist of the chillers where the CW will be generated, and the secondary loop will be the distribution circuit consisting of CW coils in air-handling units and fan coil units, through which CW will be conveyed to the load. A typical primary/secondary arrangement is shown in *Fig. 1.1*. The bypass piping between the primary and secondary allows the pumping systems in these loops is to be decoupled and the speed of the secondary distribution pump is to be varied to match the cooling load. A transducer located downstream at the furthest loop is set to maintain minimum pressure head differential required to meet the peak load requirements at that point. This provides a signal to the variable speed drive control to vary the speed of the secondary pump to maintain the pressure head differential. This results in a reduction in the brake horsepower requirements of the secondary pump at part load conditions.

In order to be able to vary the speed, the CW coils must be controlled using two-way valves. The existing system consists of three-way, two-position control valves at the fan coil units, which would be converted to two-way valves by shutting off the bypass. New two-way valves will be installed at some of the air-handling unit CW coils that at present do not have any automatic control valves. As the load in the system drops, these two-way valves will close causing the secondary pump to “ride the curve”, which will tend to increase the pressure in the system. A differential pressure sensor, located at the furthest point in the circuit from the pump, will sense this rising pressure and send a signal to the Variable Speed Drive (VSD) to slow the pump and eliminate generation of any excessive pressure. This reduction in speed will cause the secondary CW flow rate to go down in proportion to the speed. As this occurs the primary loop flow rate will be greater than in the secondary, and the difference will bypass to the chiller return water where it will mix with the CW return from the system. The result is a reduction in the overall chiller return water temperature.

A temperature sensor located in the chiller supply main header piping will unload the chillers to maintain the CW supply temperature set point. Chiller sequencing will be accomplished via a flow sensor located in the secondary loop and a chiller plant controller. As the load decreases, the secondary pump will be slowed to decrease the flow. The flow sensor will provide an input signal to the chiller plant controller. When this signal indicates flow below a set point, a chiller will be disabled, and similarly, as the load increases, an additional chiller will be enabled. Once a chiller is enabled, its own controller will load and unload the chiller to maintain a set CW supply temperature. The primary CW pumps are interlocked with their respective chiller to run only when that chiller is enabled.

Energy Savings And Economics of Implementing ECO
The existing CW system is controlled manually. Chillers and pumps are brought on-line as needed to maintain a relatively constant CW supply temperature. The annual energy consumption of the existing CW system was estimated based on the number of hours a month the CW pumps ran. This information, along with the pumps horsepower, utility electrical rates, and cooling load distribution, were obtained and used to estimate the total annual electrical energy used for chilled water pumping in the facility. This data is presented in *Table 1.1.*

The energy savings were calculated by subtracting the energy consumption of the new pumping arrangement from the estimated energy consumption of the existing pumping system (see *Tables 1.1* and *1.2*):

Annual Energy Savings: 671,393 - 399,444 = 271,949 kWh

Annual Cost Savings: Rs. 2,014,179 - Rs. 1,198,332 = Rs. 815,847 (US$ 26,317)

Implementation Costs (*Table 1.3*): Rs. 3,370,072 (US$ 108,712)

Simple Payback: Rs. 3,370,072/Rs. 815,847 = 4.1 years

Figure 1.1

Typical Variable Speed Pump System Using 2-Way Valve Control & Reversed Return Piping

ECO #2

DIRECT-FIRED ABSORPTION CHILLER(S)

Description of ECO

The four existing electric chillers would be replaced with two 700-ton Lithium Bromide absorption chillers that use Light Diesel Oil (LDO) as their fuel. The units studied are two-stage units in lieu of single stage units simply because of their higher Coefficient of Performance (COP). Higher COP units use less fuel and so compete better with electric chillers.

These units can be installed after removal of the existing electric chillers and with some modifications to the existing cooling tower and chilled water piping inside the chiller plant room. LDO supply piping and combustion intakes would also be required. Also, the products of combustion will need to be removed via a chimney venting system.

Energy Savings And Economics of Implementing ECO

The economic feasibility of absorption cooling is dependent upon the cost of the alternative fuel sources. In this case, the two fuels are LDO and electricity. The utility rates for both electricity and LDO and the approximate monthly run time and COP of the existing chillers were obtained from the hotel's mechanical staff (see *Table 2.1*).

The energy-use estimates of the existing system and the direct-fired absorption chillers are given in *Tables 2.1* and *2.2*. The system COP used for the existing electric chillers includes the energy for the auxiliary equipment such as cooling tower fans and pumps. This auxiliary load will also exist for the absorption units and is taken into account in *Table 2.2.*

Annual Energy Savings:

Electric 5,645,592 - 370,371 = 5,275,221 kWh

Light Diesel Oil - 83,882 MMBtu[1]

Annual Cost Savings:

Rs. 16,936,774 - Rs. 16,797,012 = Rs. 139,762 (US$ 4,509)

Implementation Costs (*Table 2.3*): Rs. 28,923,000 (US$ 933,000)

Simple Payback: Rs. 28,923,000/ Rs. 139,762 = > 20 years

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[1] The negative sign indicates an increase in energy use due to fuel switching

ECO #3

HIGH-EFFICIENCY CENTRIFUGAL CHILLERS

Description of ECO

The two existing 120-ton electric chillers and two 600-ton centrifugal chillers are approximately thirteen years old. The efficiency of these chillers is lower than that of chillers available today. Also, the existing chillers use R-11 which is a CFC refrigerant and will no longer be produced after 1995. The replacement costs for these refrigerants are expected to rise significantly, making the operation of these machines potentially very expensive if refrigerant were to leak out and need replacement.

This ECO looks at replacing all the existing chillers with three 500-ton, high-efficiency centrifugal chillers that have a lower kW/Ton rating. These units can be installed after removal of the existing electric chillers and following modifications to the existing cooling tower and chilled water piping inside the chiller plant room.

Energy Savings And Economics of Implementing ECO

The approximate monthly run time and kW/Ton of the existing chillers, along with the electric utility rates, were obtained from the operating staff.

The energy-use estimates of the existing system and the high-efficiency centrifugal chillers is given in *Table 3.1*. The kW/Ton used for the existing electric chillers does not include the energy for the auxiliary equipment, such as cooling tower fans and pumps. Although we are looking at the differences in the two systems, the auxiliary loads are the same in each case.

Annual Energy Savings: 1,527,768 kWh

Annual Cost Savings: Rs. 4,583,303 (US$ 147,848)

Implementation Costs (*Table 3.2*): Rs. 13,485,000 (US$ 435,000)

Simple Payback: Rs. 13,485,000/ Rs. 4,583,303 = 2.9 years

ECO #4

COOLING TOWER PLANT CONTROLLER

Description of ECO

At the present time, the cooling tower fans and pumps are brought on manually to meet the system load. The cooling towers are operated to maintain a condenser supply temperature of 30°C (86°F). With a cooling tower plant controller, starting and stopping of these fans and pumps could be controlled to match the system load more precisely than is achievable under the current mode of operation. Also, during milder, cooler weather, the condenser supply water temperature set point could be reset to a lower value resulting in more efficient chiller operation.

Energy Savings And Economics of Implementing ECO

It is estimated that for every 1°F the condenser water temperature is lowered, the efficiency of the chiller increases by one percent. This information, along with existing condenser supply temperatures, fan, and pump horsepower, and approximate hours of operation obtained from the hotel's mechanical staff, were used to estimate the potential energy savings. The savings accrue during the milder temperature months and are presented in *Table 4.1*:

Annual Energy Savings:	110,109 kWh
Annual Cost Savings:	Rs. 330,326 (US$ 10,655)
Implementation Costs (*Table 4.2*):	Rs. 465,000 (US$ 15,000)
Simple Payback:	Rs. 465,000/ Rs. 330,326 = 1.4 years

ECO # 5

PROVIDE A DEDICATED FACILITY ENERGY CONSERVATION STAFF

Description of ECO

This ECO is to provide separate staff within the technical department to identify, implement, and track progress of energy saving measures. The staff should include one engineer with a background in energy conservation and facility operations. In addition, the staff should include two technicians for implementation and identification of ECOs. One of the technicians should be an electrician, and the other should be a mechanical person familiar with steam, HVAC, and water systems. Qualifications for these positions are provided in this section.

This team would identify new energy conservation opportunities by physical inspections of the hotel as well as receiving input from other hotel staff. As opportunities are identified, they would be pursued to determine potential. A priority list of projects would then be established, and funding applied for through in-house and outside sources.

To estimate the value of hiring dedicated energy conservation staff, an assumption of 1% savings will be attributed to the additional awareness and prompt implementation of energy conservation gained by the presence of this staff. A 1% maintained savings will pay the salaries of the additional staff and will provide a profit above the additional payroll expense.

Energy Savings and Economics of Implementing ECO

Annual Energy Cost Savings:	Rs 606,670 (US$ 19,570)
Implementation Costs: (annual salaries)	Rs. 360,000 (US$ 11,613)
Annual Profit From Hiring Additional Staff:	Rs. 246,668 (US$ 7,957)

Qualifications of Dedicated Energy Conservation Staff
A three-person energy conservation team should consist of one energy engineer and two technicians. The following are qualifications suggested for each of these positions.

It is stressed that this staff should be utilized only for energy conservation activities.

Energy Engineer
- 5 to 10 years of experience
- 3 years (minimum) of energy conservation experience
- mechanical or electrical engineering degree
- Knowledge of both mechanical and electrical systems
- Able to interact with all facility staff
- Able to create computer spreadsheets
- Understands financial payback calculations

Electrical Technician
- 5 years of experience
- Understands drawings and schematics
- Able to work with single- and three-phase wiring
- Understands basic control strategies
- Able to meter electrical loads
- Interested in energy conservation

Mechanical Technician
- 5 years of experience
- Understands drawings and schematics
- Able to work on steam and water piping
- Understands pump and fan mechanics
- Understands boiler operations
- Interested in energy conservation

ECO # 6 - LIGHTING EFFICIENCY UPGRADES

Description of ECO

This recommendation is to retrofit a portion of the existing facility lighting with lighting sources which put out more light per watt of electricity. Over the life of the new lighting sources, they will save many times more in energy cost than their purchase price. In addition to the energy cost savings, the longer life technologies will reduce the time spent by maintenance staff changing light bulbs and ballasts.

The high-efficiency lighting technologies which will benefit this facility are electronically ballasted compact fluorescent lights (CFLs), electronic ballasts for four-foot tube lights, triphosphor fluorescent tube lamps, and metal halide lights for exterior night lighting.

Compact fluorescent lights

Compact fluorescent lights (CFLs) are designed to replace incandescent light bulbs. Using fluorescent lighting technology, CFLs are four to five times more efficient than traditional incandescent light sources. In addition, they have a lifetime of 10 to 12 times longer than an incandescent bulb. First-generation CFLs had poor light quality which discouraged interior designers from approving their use. Presently, CFLs are designed to closely match the light of frosted incandescent light bulbs. The CFLs are a well established lighting source in U.S. commercial buildings. Quality CFLs are available in India, although the larger lighting companies must be contacted to find local outlets. Phillips, General Electric, and Osram Sylvania all carry high-efficiency lighting sources in India.

Energy Savings and Economics of Implementing ECO

Annual Energy Saved: 211,610 kWh

Annual Electrical Cost Savings: Rs. 664,717 (US$ 21,442)

Implementation Costs: Rs. 1,230,510 (US$ 39,694)

Simple Payback: 1.9 years

ECO # 7

BOILER EXHAUST STACK HEAT RECOVERY

Description of ECO
Boiler stack heat recovery takes high-grade heat from the exhaust stack and transfers it to a lower temperature substance. This recommendation is to use boiler exhaust gases to preheat boiler make-up water. The temperature of the existing flue gases are 211°C (412° F). The temperature of the boiler make-up water is 71°C (160°F). By preheating the boiler feedwater using stack gases, the heat normally lost is recovered and put back into the steam generation process.

Energy Savings and Economics of Implementing ECO

Annual Energy Saved: 53,836 liters of LDO (1,963 MMBtu of LDO)

Annual LDO Cost Savings: Rs. 368,249 (US$ 11,879)

Implementation Costs: Rs. 279,000 (US$ 9,000)

Simple Payback: 0.76 years

The following pages include the energy savings analysis and equipment selected for this opportunity.

ECO # 8

BOILER FUEL ATOMIZATION AND BURNER MODULATION CONTROL

Description of ECO

This opportunity has two components for improving boiler efficiency. The first is to retrofit the boiler burner so that it can be made to modulate with the steam demand. The second is to atomize the fuel using compressed air rather than just the pressure from a mechanical fuel pump.

Burner Modulation Control

Instead of regulating the boiler based on high/low/off control, the burner modulates to produce the amount of steam which is demanded at the time. The control is based on the steam header pressure so that the pressure of steam in the system will be consistent. This opportunity saves energy by elimination of losses which occur when the boiler is cycled on and off. In addition, this measure reduces wear on the boiler and support equipment by reducing cycling and thermal stress.

Boiler Fuel Atomization with Air

This method of atomization provides an improved flame pattern regardless of the boiler load or the variance in fuel viscosity. Although additional energy is expended in production of compressed air, the gain made by having a consistent flame pattern will surpass the compressed air energy investment. This measure optimizes flame pattern with both varied load as well as varied fuel consistency.

Energy Savings and Economics of Implementing ECO

Annual Energy Saved: 23,100 liters of LDO (842 MMBtu of LDO)

Annual LDO Cost Savings: Rs. 158,007 (US$ 5,097)

Implementation Costs: Rs. 682,000 (US$ 22,000)

Simple Payback: 4.32 years

Two steam boilers are installed at the boiler house of the Hyatt Regency Hotel. The main parameters of these boilers are the following:

Capacity	--	2,000 kg/hr (4,400 lb./hr), each
Maximum pressure of steam (saturated)	--	10.54 kg/cm^2 (150 psig)
Fuel consumption	--	156 liters/hr (41 gal/hr)
Manufacturer	--	Wester Work, Model WPO-20

One boiler is kept in operation, and the second one in stand-by mode. During late night hours (11 p.m. to 6 a.m.) both boilers are shut down.

This ECO switches to continuous boiler operation. This will require the installation of a new burner and control system.

Significant additional fuel savings will occur if the existing mechanical atomization system is replaced by compressed air atomization.

To quantify potential savings, the chart below uses empirical data to estimate energy savings with various control schemes. The following chart is from the Boiler Plant and *Distribution System Optimization Manual* written by Harry R. Taplin, Jr., P.E., C.E.M.

	Efficiency at % Load			
Control Type	25%	50%	75%	100%
On/Off	70.3%	74.4%	75.6%	76.3%
On/Off with Flue Damper	73.3%	75.3 %	76%	76.3%
High/Low/Off	76.9%	76.5%	76.4%	76.3%
Modulating	76.9%	77.7%	77.2%	76.3%

According to the same reference, the substitution of burners which atomize oil by using air as opposed to burners which inject oil with mechanical pressure provides an energy savings of 2% to 8%.

Analysis

A conservative energy savings estimate of 3% was used to calculate the accumulated effects of implementing both continuous boiler operation and air atomization of fuel.

It is assumed that the average boiler load is 80% and that one of the two boilers is always on stand-by.

Annual hours of operation
B 365 days/yr * 17 hr/day = 6,205 hrs

Annual fuel consumption
A 24 liters/hr * 6,205 hrs/yr = 770,000 liters

Annual expenses on fuel
C 770,000 liters/yr * Rs. 6.84/ liter
= Rs. 5,266,800 (US$ 169,897)

Where:
Rs. 6.84 = cost of 1 liter of LDO in local currency
Rs. 31/US$ = rate of currency exchange

Annual fuel cost savings
CS = Rs. 5,266,800 * 3% = Rs. 158,004 (US$ 5,097)

Simple Payback
PB = $US 22,000 / $US 7,025 = 4.3 years

The following pages present descriptions of the burner selected for this analysis.

ECO # 9

BOILER INSULATION UPGRADE

Description of ECO

This opportunity involves application of insulation to the front and back ends of the existing boilers. Boilers lose heat out of their shells. The sides of boilers are typically well insulated because they are not a point of access. The ends of the boiler however are accessed on an annual basis for maintenance. For this reason, insulation is typically not present. Average temperatures of 150°C (300°F)were observed on the front of the boiler, and 110°C (230°F) were observed on the rear of the boiler.

This ECO assumes insulation of the front and rear of the boilers with two inches of fiberglass board or blanket insulation. The installation is to be such that it is either removable or does not inhibit routine maintenance or annual overhauls. This insulation will save fuel costs as well as reduce boiler room temperature.

Energy Savings and Economics of Implementing ECO

Annual Energy Saved:	2,250 liters of LDO (82 MMBtu of LDO)
Annual LDO Cost Savings:	Rs. 15,252 (US$ 492)
Implementation Costs:	Rs. 13,702 (US$ 442)
Simple Payback:	0.9 years

The following pages present the analysis done to estimate the cost-effectiveness of this ECO.

ECO # 10

STEAM DISTRIBUTION / CONDENSATE RETURN EFFICIENCY

Description of ECO

The distribution of steam and the return of its condensate present opportunities for energy conservation. A detailed examination of the steam distribution system and condensate return was not carried out during the survey. This ECO involves the implementation of an routine steam distribution and condensate return survey to identify and eliminate heat loss sources. Common areas to increase efficiency include the following:

- Find and repair leaks in steam piping and valves
- Find and repair leaks in condensate piping and valves
- Find and repair leaking steam traps
- Return all steam condensate possible to the boiler
- Monitor amount of condensate returned to the boiler and its temperature
- Find and repair damaged or missing steam piping insulation
- Find and repair damaged or missing condensate piping insulation
- Eliminate unused steam lines which contribute to loss but no longer distribute steam
- Reduce pressure in steam lines where possible

Energy Savings and Economics of Implementing ECO

A specific estimate of savings is not being quantified for this measure. Instead, the following pages contain charts which quantify the value of locating and repairing steam and condensate losses. In addition, as steam using equipment is modernized and repaired, it is worthwhile to re-evaluate the steam distribution system to insure losses are minimized.

An example of savings is to repair a valve steam leak with 1/16 of an inch equivalent hole. Assuming the system is at 100 psi, the annual loss in energy cost is US$ 998. Because of steam’s high energy content, it is important to identify and repair steam leaks immediately.

A second example of savings is to repair a condensate loss with the equivalent area of 25 square millimeters. This may be a valve which requires repacking. In a year’s time, the loss would be Rs.1,595 (US$ 51.46). One leak in itself does not create a significant energy loss, although most facilities have numerous leaks of this type. When the value of each leak is added together, the total loss becomes significant. Metering boiler feed water and blow-down water is a good way to identify condensate losses.

ECO # 11

GUEST ROOM LIGHTING CONTROL

Description of ECO

This opportunity is to install a guest room control which eliminates lighting energy waste while the room is unoccupied. When the lighting in a vacant guest room is left on, it may be on because the guest left it on, or because the housekeeping staff switched it on to greet the guest with a well-lit room. The purpose of installing this control is to shut off lights when the room is unoccupied and quickly turn the lights on when the guest returns. Controls of this type are typically activated by placement of the guest's key in a storage slot located in the entry way. After the key is removed, all room lights are shut off except for the entry light. For safety and convenience, lighting in the entry is controlled by a motion switch when the key is removed. When the guest(s) re-enter the room, the motion of the door turns on the lighting in the doorway. This allows the guests to store their keys in a well-lit area. When they set their key in the storage slot, all lighting returns to the way it was when the guest left.

Energy Savings and Economics of Implementing ECO

Per Room

Annual Energy Saved: 383 kWh of electricity

Annual Energy Cost Savings: Rs. 1,147 (US$ 37)

Implementation Costs: Rs. 6,200 (US$ 200)

Simple Payback: 5.4 years

For 525 Rooms

Annual Energy Saved: 201,075 kWh of electricity

Annual Energy Cost Savings: Rs. 603,386 (US$ 19,464)

Implementation Costs: Rs. 3,255,000 (US$ 105,000)

See the following page for the cost-savings analysis and guest occupancy assumptions

ECO 12

SOLAR PREHEATING FOR DOMESTIC HOT WATER

Description of ECO

This recommendation is to preheat domestic hot water with solar panels. Presently, the water which is heated for domestic hot water begins at 20°C (68°F). Using steam, it is then heated to approximately 55°C (131°F). This measure saves energy by preheating the 20°C water to approximately 32°C (90°F) using solar panels mounted on the roof of the building. By doing this, one-third of the energy used to heat hot water is provided by the sun.

The fresh water supply will first circulate through the solar panels, and then it will enter the calorifier. If the weather is not favorable for solar heating on a given day, the water will still be heated to desired final temperature in the calorifier. For nighttime hot water usage beyond the stored amount, the calorifier would make up the shortfall.

Energy Savings and Economics of Implementing ECO

Annual Fuel Saved: 138,167 liters of LDO (5,047 MMBtu of LDO)

Annual LDO Cost Savings: Rs. 945,066 (US$ 30,486)

Implementation Costs: Rs. 5,251,400 (US$ 169,400)

Simple Payback: 5.6 years

The following page presents the analysis which was done to quantify this opportunity.

ECO # 13

HIGH-EFFICIENCY MOTORS FOR AIR-HANDLING UNITS

Description of ECO

This would replace 37 existing, air-handling unit motors with high-efficiency motors. The savings from improved energy efficiency will pay to abandon the remaining motor life.

Motors lose energy in several ways. The largest areas include the following items:

Copper losses that result naturally from current passing through the copper-wire windings

Premium efficiency motors use larger diameter copper wire to decrease these losses. This adds 35% to 40% more copper in a high-efficiency motor.

Magnetic core loss

To accommodate the larger wire, the steel lamination that support the windings need larger wire slots. This requires more laminations to be put in each motor. Most standard-efficiency motors use low-carbon steel laminations. Premium-efficiency motors have high-grade silicon steel laminations which cut core losses in half. Special annealing and plating of rotor and stator components, plus use of high-purity aluminum rotor bars also reduce core losses.

Friction loss

Higher-grade bearings reduce friction loss.

Other

In addition, windage loss in fan-cooled motors is reduced by smaller, more efficient fan design.

Overall, generally tighter tolerances and more stringent manufacturing process control are applied to minimize losses from unplanned conducting paths and stray load phenomena.

Because of the reduced operating temperature of high-efficiency motors, their insulation and bearings last longer than standard-efficiency motors.

Energy Savings and Economics of Implementing ECO

Annual Energy Saved: 109,150 kWh

Annual Energy Cost Savings: Rs. 327,450 (US$ 10,563)

Implementation Costs: Rs. 604,469 (US$ 19,499)

Simple Payback 1.85 years

ECO # 14

WATER CONSUMPTION REDUCTION

Description of ECO

This opportunity implements measures which reduce water consumption in the facility. This saves energy in two ways. The first savings is that of heated water, and the second is a savings of pump energy required to pressurize and move the water to the end use. Additional financial benefits are seen by reduction of water costs.

Reduction can come from two opportunities. The first is to install water aerators in guest room faucets and shower heads. This will make the water flow "feel" the same to the end user, but will reduce the actual consumption by about 50%. This is accomplished by mixing air in with the water stream. This is not the same as just inserting a flow restrictor in the faucet or shower. Flow restrictors save water, but reduce occupant comfort. The second conservation opportunity is to routinely inspect water piping and water using devices for unwanted leakage. Leakage is common in toilets, faucets, and shut-off valves. Although these leaks may be relatively small, they add up to large water and energy loss.

SHOWER AND FAUCET AERATORS

Shower and faucet aerators will cut guest room consumption of both hot and cold water. They reduce the water used in the shower and in the sink by about 50% while leaving the user with the same comfort as before. This also provides the benefit of reducing the demand on the water supply system during peak usage periods.

WATER LEAKS

Water leaks in toilets, faucets, showers, and other valves add up to a large loss because they are continuous. Housekeeping staff is an excellent resource to identify many of these leaks. With prompt repair, significant water consumption can be saved. Although the energy savings from fixing leaks is modest, the repair costs are typically minimal.

Energy Savings and Economics of Implementing ECO

This savings from this ECO are based on 525 rooms retrofitted with aerated faucets and shower heads, and an annual average occupancy of 400 guests per day. Using the shower and the sink, each guest is assumed to use sixteen gallons (60 liters) of hot water, and 20 gallons (76 liters) of cold water per day.

Annual Energy Saved:
    Electrical   2,725 kWh

Fuel 24,021 liters of LDO

Annual Energy Cost Savings: Rs. 172,143 (US$ 5,553)

Annual Water Cost Savings: Rs. 104,842 (US$ 3,382)

Implementation Costs: Rs. 244,125 (US$ 7,875)

Simple Payback: 0.88 years

APPENDIX HR-B
Photographs

Appendix HR-B   Photographs

Photo 1 - Hyatt Regency: Vice President of Engineering, Mr. T.N. Rai, Displaying Energy Use Graphics

Photo 2 - Hyatt Regency: Chiller Plant Operator with Centrifugal Chiller #2

Photo 3 - Hyatt Regency: Boiler Operator Displaying One of Two Steam Boilers

Photo 4 - Hyatt Regency: Survey Team Member and Hotel HVAC Operator Taking Flow Measurements on an AHU

APPENDIX HR-C
Contacts

General Facility Information

Name of Facility	Hyatt Regency Hotel.
Mailing address	Bhikaiji Cama Place - Ring Road New Delhi - 110066
Phone	(91) (11) 688-1234
Fax	(91) (11) 688-6833 or 687-6437

Facility Contacts

Mr. T.N. Rai, Vice President of Engineering

Mr. K.C. Pillai, Assistant Director of Engineering

Mr. Subrata Mukherji, Chief Steward